U.S. DEPARTMENT OF ENERGY

OFFICE OF SCIENCE

Closeout Report by the Review Committee

for the

Muon to Electron (Mu2e) Conversion Project

Fermilab

June 7, 2012

Daniel R. Lehman

Review Committee Chair

Office of Science, U.S. Department of Energy

http://www.science.doe.gov/opa/

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Review Committee Participants

OFFICE OF SCIENCE

SC1
Accelerator Physics

* Rod Gerig, ANL

SC2
Superconducting Solenoids

* Peter Wanderer, BNL
Bruce Strauss, DOE/SC

SC3
Detector Systems

* Steve Kettell, BNL
Douglas Bryman, TRIUMF
Rik Yoshida, ANL

SC4
Electronics/DAQ/Control Systems

* Rick Van Berg, U of Penn.

SC5
Civil Construction

* Jeff Sims, ANL

SC6
Cost and Schedule

* Ethan Merrill, DOE/SC
Rick Blaisdell, DOE/OECM
Brian Huizenga, DOE/OECM

SC7
Project Management and ES&H

* Dick Loveless, U. of Wisconsin
Kurt Fisher, DOE/SC

Observers

Ted Lavine, DOE/SC
Alan Stone, DOE/SC
Mike Weis, DOE/FSO
Paul Philp, DOE/FSO

LEGEND

SC Subcommittee
* Chairperson

Count: 14 (excluding Observers)

Charge Questions

1. Does the conceptual design satisfy the performance requirements?

2. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration?

3. Does the proposed project team have adequate management experience, design skills, and Laboratory support to produce a credible technical, cost and schedule baseline?

4. Are ES&H aspects being properly addressed and are future plans sufficient given the projects current stage of development?

5. Is the documentation required by DOE, satisfying Order 413.3B, ready for approval of CD-1?

Accelerator (WBS 1.2), Muon Beamline (WBS 1.5)

1. Does the conceptual design satisfy the performance requirements? *Yes*

2. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration? *Yes, but suggest several percent increase for installation activities.*

5. Is the documentation required by DOE, satisfying Order 413.3B, ready for approval of CD-1? *Yes*

Findings

- Extensive amount of work in these two WBS elements – it is more than appears (from the cost) due to extensive reuse of existing equipment.
- **Accelerator (WBS 1.2)**
  - Recycler RF & Extraction
  - Rings & Transport to Rings
  - Radiation Safety Improvements
  - Resonant Extraction System
  - Delivery Ring RF
  - External Beamline
  - Extinction
  - Target Station

- **Muon Beamline (WBS 1.5)**
  - Vacuum System
  - Collimators
  - Muon Beamline Shielding
  - Stopping Target
  - Stopping Target Monitor
  - Proton Absorber
  - Muon Beam Stop
  - Neutron Absorber
  - Detector Support Structure
  - Systems Integration, Test & Analysis

Findings

- Dependent on g-2 (estimates)

g-2 project	
Recycler RF system	6,900
RR extraction kicker and beam line stub	2,600
Connection of M3 line to Delivery Ring	1,500
Upstream External beamline	
magnets	703
PS	918
mechanical+inst	240
total from g-2 project	12,861

- Delays in g-2 will adversely effect mu2e schedule

Findings

- Dependencies on other Fermilab Funding (estimates)

	$K
Ring AIP	9,700
Cryo AIP	8,000
Beam line GPP enclosure	9,200
Site Prep GPP	3,200
Total of required AIP and GPP	30,100

Comments

- Committee concurs that this work scope will be done on schedule, cost estimates of work evaluated are thorough
- Risk analysis is thorough for this stage of project, and positions it well for the future.
- Physics requirements and interface issues are defined, but some remain to be finalized, there are many interfaces.
- Conceptual Design work is well advanced across this work scope

Comments

- As in other areas of the project, many staff leave the project for a year or more between design, and fabrication and installation.

- Alternatives have been considered in most areas, many areas retain alternative approaches. R&D is being done in key areas to identify alternative solutions and reduce risk. (e.g., Extinction, Resonant Extraction, Muon vacuum systems)

Comments

- Some hardware reuse may not work out and new hardware will be needed. Controls is a particular area of concern
- Beam loss issues are a concern, ES&H section at Fermilab has chosen to place limit 100X lower than DOE Order. Extensive interlock systems are being developed to enforce limit which could limit operation.
- High level software applications not included in project

Comments

- Installation costs are spread through each level 3 WBS. An overall evaluation and roll-up of installation costs before CD-2 is advised.

- The committee is concerned about the dependencies on off project activities, particularly those associated with another Project (g-2). See “Management” recommendation.

- Technical peer design reviews at each level 3 element should be done before CD-2

Recommendations

1. Appoint a project wide installation coordinator before CD-2. Fully reevaluate all installation costs and incorporate into CD-2 baseline.

2.2 Superconducting Solenoids

P. Wanderer, BNL; B. Strauss, DOE / Subcommittee 2

1. Does the conceptual design satisfy the performance requirements? YES

2. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration? Point costs are reasonable as is the schedule.

5. Is the documentation required by DOE, satisfying Order 413.3B, ready for approval of CD-1? YES

Findings

- Considerable detailed paper studies have been completed on the magnet system.
- The construction methods proposed are similar to those of other large detector systems within the field of high energy physics.
- We concur with technical findings from the previous director's review
- One model coil is under construction in industry at this time.
- There are a number of acquisition proposals. In each of these proposals significant fabrication will be done by outside vendors. Initial procurement specification packages have not been generated.
- Schedule contingency has been accounted for by transforming into a risk with attendant cost consequences.
- The Transport Solenoid (TS) is on the project critical path and the Detector Solenoid (DS) is not far behind.
- Scope contingency was not identified in the presentations.
- As presented the low end of the cost range is the cost of the point design; the high end is the low end cost plus contingency.

- **Comments**

- Budgetary information has been received from four vendors and was used in setting up the project budget. However, this information is not binding.
- The conceptual design owes a debt to the CERN staff member who spent a sabbatical year at FNAL and who is still listed as a Level 3 manager.

- **Recommendations**

1. Prepare at least one of the initial specification packages by the next mini review.
2. Prepare an initial plan for contract/procurement oversight of vendors by the next mini review.
3. Explore the possibility of early procurement of superconductor by the next mini review.
4. Consider the possibility of initiating practice PS and DS coil winding by additional vendors and the lab by the next mini review.

1. Does the conceptual design satisfy the performance requirements? **"Yes"**

Preliminary studies indicate that the system **may** be able to meet the **performance requirements**. To fully establish that the proposed system will meet the very challenging performance requirement of **2×10^{-17}, further evaluation** of all factors pertaining to the **acceptance** should be completed to provide a **firm estimate** of the uncertainty with high confidence.

1. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration? **Yes**

5. Is the documentation required by DOE, satisfying Order 413.3B, ready for approval of CD-1? **Yes**

Detector Systems and Trigger/DAQ

- **Comments**
  - Installation and integration is managed in WBS 5.10. Attention to **good communications** should be continued.
  - The current CD-3b date has created a **gap** in detector systems **schedules** that is cause for concern over potential **loss of momentum** and experienced personnel.
  - The cost books were hard to evaluate due to the combination of costed and uncosted labor hours and the **classification of non-Fermilab labor as M&S**.

- **Recommendations**
  - **Improve background rate simulations** for **refining requirements** and **design decisions** in support of CD-2.
  - Develop and document a **quantified assessment of uncertainties** in the overall **acceptance** prior to CD-2.

Tracker

- **Comments**
  - **Labor** allocated for straws and straw assemblies appears **light**.
  - **Tracker is on track** to refine the present conceptual design into a preliminary design that fully matches the functional requirements of the experiment.

- **Recommendations**
  - Continue to refine calculations of the **expected rates** in the tracker system through complete simulations to evaluate the **efficiency** for detecting signal electrons and detailed **requirements for the electronics**

Calorimeter

- **Comments**
  - The **calorimeter** is an **important** element of the experiment that provides a **valuable redundant signal definition**.
  - **Calorimeter requirements** "to confirm that a reconstructed track is well measured" are **reasonable** (position resolution of 1cm, energy resolution of 2% and time resolution of <1ns).
  - **Sharpen justification of the calorimeter requirements** with more detailed studies.
  - **Cost** model and vendor quotes for LYSO **crystals look good**, but caution is urged based on previous HEP crystal procurement experience.

- **Recommendations**
  - Given the **importance of INFN** to the Calorimeter system, project management should proceed with all reasonable timeliness to **formalize the INFN contribution** to Mu2e

Cosmic Ray Veto

- **Comments**
  - The proposed extrusion of scintillator by NICADD is **well matched** to the needs.
  - **SiPM readout appears promising**. At neutron fluxes $>10^8$ n/cm^2 additional shielding and/or alternative technologies may be required.
  - **Plans to develop module fabrication procedures** with mockups or prototypes and a vertical slice test **are well thought out**.
- **Recommendations**
  - **Consider possible experiments** to measure the production of 105 MeV electrons from cosmic muons to **validate simulations** used for the **background** estimate.

1. Does the conceptual design satisfy the performance requirements? "**Yes**"

2. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration? **Yes**

5. Is the documentation required by DOE, satisfying Order 413.3B, ready for approval of CD-1? **Yes**

- **Findings**
  - The tracker, calorimeter, cosmic ray veto and DAQ projects presented plausible and fairly detailed conceptual designs.
  - The tracker, calorimeter and cosmic ray veto groups are actively pursuing designs and prototypes to cover the riskier parts of their charges.
  - The DAQ project is pursuing a low risk, essentially all commercial hardware, design.
  - The projects all presented detailed costs and schedules appropriate to CD1 level of maturity.

- **Comments**
  - The DAQ plan, as presented, retains some obsolete tasks and some apparent duplication and reduplication adding to a **large total number of man hours** – two thirds of which are costed on the project.
  - The tracker electronics ASIC development could suffer from **extended gaps in the schedule** and might benefit from a rethinking of when "final prototype" work should actually begin.
  - The ASIC design team has not yet carefully considered packaging options especially as they affect the number of channels per die. **A more integrated design approach** might result in a different optimum number of channels than presently imagined.

- **Comments**
  - The **front end to DAQ interface** is, at the moment, largely undefined. Progress on the front ends and the DAQ would be expedited by a timely agreement on the details of that interface and the underlying protocol(s).
  - **The lack of firm estimates of radiation fields** (charged particle and neutrons) at various locations in the experiment leave some uncertainty on the acceptable technologies for a given detector – e.g. FPGAs, SiPMs, even scintillation counter cosmic ray detectors.
  - **The lack of firm estimates of radiation fields** also introduces uncertainty in the measurement requirements that the electronics must meet.

- **Recommendations**
  - **Generate a new bottoms up cost estimate for the Trigger and DAQ in time for CD2.**
  - **Generate detailed and reliable estimates of background radiation (species, energy spectra and flux) at various points within the detector in order to support the upcoming design decisions and prepare for CD-2.**

3. Civil Construction

J. Sims, ANL/Subcommittee 5

1. Does the conceptual design satisfy the performance requirements? **Yes, the civil design appears to be adequately mature for CD-1.**

2. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration? **Yes, the schedule and cost estimate for the detector hall appears to be appropriately detailed for this level of design.**

5. Is the documentation required by DOE, satisfying Order 413.3B, ready for approval of CD-1? **Yes, for the Detector Hall a conceptual design with documentation of appropriate sustainability considerations exists and an external design review has been performed.**

3. Civil Construction

J. Sims, ANL/Subcommittee 5

Findings

- A conceptual design of the Detector Hall has been prepared by FESS Engineering including guiding principle sustainability considerations.
- The Conventional Facilities scope required to deliver beam to the Mu2e Detector Hall is captured in two Accelerator Improvement Projects (AIP), and three General Plant Projects (GPP). A detailed Muon Campus Program Plan was developed to coordinate these projects.
- A construction estimate for the detector building has been developed resulting in a total $13.5M with indirect and escalation. An independent estimate validated the cost.
- Civil design requirements have been collected from technical areas and compiled in Mu2e CF Requirements Specifications and is in the process of being signed off by stakeholders.

Findings

- A categorical exclusion is anticipated for the detector hall construction. A waiver from Corps of Engineers has been obtained that determined the wetlands that are impacted by this project are not jurisdictional. An abandoned water well will need to be sealed prior to construction.
- MARS calculations have been performed to defend the current civil design radiation shielding. Cooling methods for the absorber will be determined in preliminary design.
- Value Engineering efforts in 2011 saved over $16M in civil construction cost with change from 25kw to 8kw beam.
- The conceptual design has undergone internal and external design reviews.

3. Civil Construction

J. Sims, ANL/Subcommittee 5

Findings

- Break out presentations including, requirements development, sustainability, life safety, risk, cost, schedule, fire protection, mechanical, electrical and staffing were provided.
- Two WBS activities were traced from the resource loaded schedule through basis of estimate and cobra (indirects and escalation) and found to match the project roll up WBS 3 values.
- The civil schedule includes preliminary design in FY13 followed by a 6 month gap before starting final design after CD-2 approval in FY14. Construction duration of the detector hall is planned in late FY15 and is expected to last 20 months. 146 working days of float is currently estimated on the detector hall construction.

Comments

- The **Mu2e civil team is very experienced** at this size and type of construction.
- The **conceptual design is adequately mature** for CD-1.
- The conceptual design **construction cost estimate appears appropriately detailed** and defendable for this stage of design.
- **Pursue the final NEPA determination early in preliminary design**. Consider sealing of the domestic water well soon to avoid the potential for regulatory permit delays during detector hall construction.
- Conventional construction **risks appear to be appropriately detailed** and actively managed.

Comments

- Managing the program of AIP, GPP and Mu2e funded civil construction projects will be challenging. **Vigilance will be needed to ensure that scope at interface points of these smaller projects is not omitted.** Consider a periodic scope gap analysis during preliminary and final designs.
- The potentially **high magnetic fields from the solenoid may have an impact on metallic civil components** such as piping and reinforcement bars. Consider these impacts and design solutions early in preliminary design.
- The **6 month gap** between preliminary and final design could be challenging to the Architect Engineer and may not be as cost effective as a continual design process.
- With the **current aggressive construction market conditions** it may be advantageous to consider starting the civil construction sooner than late FY15.

Recommendations

1. Consider reducing the duration between preliminary design completion and final design start to support AE team continuity (evaluate within 3 months after CD-1 approval).
2. Consider accelerating the start of civil construction to take advantage of the recent aggressive construction market conditions (evaluate within 3 months after CD-1 approval).
3. Coordinate the design of interface elements within the Muon Campus Program Plan projects and Mu2e detector hall to ensure scope is not omitted (complete prior to CD-2).

4. Cost and Schedule

E. Merrill, B. Huizenga, R. Blaisdell /Subcommittee 6

2. Do the conceptual design report and supporting documentation adequately justify the stated cost range and project duration? **YES, however the Committee felt contingency amounts were low for several L2 subprojects.**

5. Is the documentation required by DOE, satisfying DOE Order 413.3B, ready for approval of CD-1? **YES**

- **Findings**
  - The project has developed a preliminary resource loaded schedule using P6 with 4,016 activities and 98 control accounts;
  - A project critical path (solenoids) has been developed, sub-project (L2) critical paths and near-critical path activities are understood;
  - Constrained activities have been minimized;
  - The project currently has 18 months (20%) of schedule contingency to CD-4;

4. Cost and Schedule

E. Merrill, B. Huizenga, R. Blaisdell /Subcommittee 6

- **Findings**

  - The project has developed a preliminary resource loaded schedule using P6 with 4,016 activities and 98 control accounts;
  - A project critical path (solenoids) has been developed, sub-project (L2) critical paths and near-critical path activities are understood;
  - Constrained activities have been minimized;
  - The project currently has 18 months (20%) of schedule contingency to CD-4;
  - A preliminary, bottoms-up cost estimate has been developed using COBRA Cost Processor;
  - The CD-1 point estimate is $229.3M with a cost range of $208.1M-$286.8M;
  - The CD-1 point estimate includes $51.6M (32%) cost contingency;
  - The project has developed a qualitative risk register used to develop the CD-1 cost range;
  - Obligations vs. Funding curves have been developed.
  - Mu2e EDIA is 37%

Comments

- Several L2 WBS activities contain internal schedule float (calorimeter, tracker); the project should **consider evaluating activity sequencing** to determine if some activities can start earlier than currently scheduled;

- Several L2 WBS activities contain resource curves with steep ramp-ups and ramp-downs; the project should **consider completing a full project-wide resource analysis and leveling exercise** to ensure the project schedule is optimized;

- For the percentage of project design complete the **Cost Range appears optimistic;**

- Schedule float of 18 months appears optimistic;

- Project risks appear to be well understood for CD-1;

Comments

- It is unlikely the future market conditions will support the current escalation rates. The project should **continue updating escalation rates** to ensure estimates reflect the latest projected market conditions;
- The project should **consider optimizing the schedule to match the funding** profile;
- The project has minimal scope contingency;
- The project should complete a parametric cost comparison with similar projects as part of preparing for CD-2.

4. Cost and Schedule

E. Merrill, B. Huizenga, R. Blaisdell /Subcommittee 6

- **Recommendations**
  - Reevaluate the cost range prior to CD-1 approval;
  - Revisit escalation rates to ensure cost estimate is not overly optimistic prior to CD-2;
  - Reevaluate the funding profile and schedule to ensure a smooth manpower ramp-up and ramp-down.

4. Cost and Schedule

E. Merrill, B. Huizenga, R. Blaisdell Subcommittee 6

Mu2e Project Status – CD-1		
Project Type	Line Item	
CD-1	Planned: 4th Qtr. FY 2012	Actual:
CD-2	Planned: 2nd Qtr. FY 2014	Actual:
CD-3a	Planned: 2nd Qtr. FY 2014	Actual:
CD-3b	Planned: 4th Qtr. FY 2015	Actual:
CD-4	Planned: 2nd Qtr. FY 2021	Actual:
TPC Percent Complete	Planned: N/A	Actual: N/A
TPC Cost to Date	$17.6M	
TPC Committed to Date	$18.2M	
TPC	$229.3M	
TEC	$177.7M	
Contingency Cost (w/Mgmt Reserve)	$51.6M	32% to go
Contingency Schedule on CD-4b	18 months	20%
CPI Cumulative	N/A	
SPI Cumulative	N/A	

4. Cost and Schedule

E. Merrill, B. Huizenga, R. Blaisdell/Subcommittee 6

WBS	Mu2e Bottoms Up Cost Analysis - FNAL	Project Estimate				DOE Review Estimate					Comment
		Base (BCWS)	Budgeted Contingency		Total	Base (BCWS)	Budgeted Contingency		Total	Delta	
		$k	%	$k	$k	$k	%	$k	$k	$k	
1	Project Management	20,491	0.4%	83	20,574						
2	Accelerator	35,362	33%	9,939	45,301						Recommend a few percent increase in contingency for installation.
3	Conventional Facilities	18,535	33%	5,979	24,514						
4	Solenoids	71,713	39%	26,520	98,233	71713	45	30600	102,313	4,080	
5	Muon Beamline	10,942	33%	3,120	14,062						Recommend a few percent increase in contingency for installation.
6	Tracker	6,971	33%	1,915	8,886						
7	Calorimeter	4,294	30%	1,270	5,564						
8	Cosmic Ray Veto	4,418	33%	1,359	5,777						
9	Trigger and DAQ	4,941	32%	1,461	6,402						The manpower estimate appears high by a factor of 2. Recommend reevaluation.
	Sub-Totals (TEC)	177,667	32%	51,646	229,313						
	Alotted Project Contingency	$51,646									
	Un-allocated TEC (contingency)	$0									
	Total Estimated Cost (TEC)	$229,313									
	Escalation	$25,000									
	Other Project Costs (OPC)	$24,177									
	Total Project Cost (TPC)				$229,313						

OECM Independent Cost Review

Reviewers: Rick Blaisdell, Brian Huizenga

ICR Purpose (prior to CD-1):

- **Validate the basis of the preliminary cost range for reasonableness and executability.** It also includes a full accounting of life cycle costs to support the alternative selection process and budgetary decisions.

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OECM Independent Cost Review

Findings

- Cost estimate maturity exceeds CD-1 requirements
- Cost estimating **processes and procedures are sound**
- Overall, "Basis of estimates" were well-defined and used sound engineering logic
- Lifecycle costs for the current scope have been identified

Recommendations

- Reconsider the project's escalation rates for the CD-2 estimate
- Consider **expanding the CD-1 cost range** consistent with AACE Class 3 / 4 estimate recommended practice
  - Project Range: $208M (-9%) - $293M (+25%)
  - OECM Recom: $208M (-9%) - $321M (+40%)

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Cost Estimate Classification Matrix For The Process Industries

	Primary Characersitic	*Secondary Characteristic*			**$229.3M Point Estimate Goal**
ESTMATE CLASS	**DEGREE OF PROJECT DEFINITION**	**END USAGE**	**METHODOLOGY**	**EXPECTED ACCURACY RANGE**	**Mu2e Notional Range**
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	
Class 4	**1% to 15%**	**Study or Feasibility**	**Equipment Factored or Parametric Models**	**L: -15% to -30% H: +20% to +50%**	**$195M - $161M $275M - $344M**
Class 3	**10% to 40%**	**Budget Authorization or Control**	**Semi-Detailed Unit Costs with Assembly Level Line Items**	**L: -10% to -20% H: +10% to +30%**	**$206M - $183M $252M - $298M**
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	
Class 1	70% to 100%	Check Estimate or Bid Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	

3. Does the proposed project team have adequate management experience, design skills, and Laboratory support to produce a credible technical, cost and schedule baseline? Yes, the current team has demonstrated the necessary skills and experience.

4. Are ES&H aspects being properly addressed and are future plans sufficient given the projects current stage of development? Yes

5. Is the documentation required by DOE, satisfying Order 413.3B, ready for approval of CD-1? Yes, draft documentation has been prepared.

Findings

- The project has minimal scope contingency.
- The Mu2e project is dependent on other projects including; The G-2 Project, Accelerator Improvement Projects, and General Plant Projects.
- Drafts of CD-1 documentation have been completed.
- Three superconducting solenoids are required for muon production, transportation and selection. The muons are stopped within a target, and the resulting electron decays are measured. Two of the three solenoids are planned to be procured commercially.
- A large cosmic ray veto surrounds the analysis area.
- A calorimeter for measuring the electron energy is located behind the Tracker. This calorimeter will be jointly delivered by Italy and US.

- **Comments**
- The project team has demonstrated ownership of the project and is commended for this successful review.

- The project management team should be acknowledged for a good job developing the plans and documentation necessary for building Mu2e. The draft documentation required for CD-1 approval is adequate.

- A number of projects for accelerator improvement (AIP), general purpose (GPP), and the recycler upgrade are necessary for Mu2e, although they are not part of the Mu2e project. Close supervision of the these projects is essential, and the PMs have instituted good contacts with these projects.

- The project team should re-evaluate and optimize the schedule consistent with the funding profile.

- Resource leveling of labor should be undertaken by the project team to address the float in the detector subsystems.

Comments

- The project team should evaluate all aspects of the solenoid procurement (i.e. “make buy” analysis).
- The committee is concerned with the interdependencies of the Mu2e, G-2, AIP, and GPP projects.
- Any delays to the G-2 project could impact Mu2e.

Recommendations

- Evaluate procuring the solenoids earlier. A draft procurement plan should be presented at a mini-review in 3 months for early procurement of the superconducting cable.
- Consider advancing the schedule of detector subsystems (especially the Tracker) in order to build and commission these detectors earlier.
- Fermilab should reevaluate the dependence of Mu2e on Projects outside the control of Mu2e.
- Ensure rapid NEPA approval.
- Expedite the CD-1 approval.
- Schedule a mini-review in three months.

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Report Outline/ Writing Assignments

OFFICE OF SCIENCE

Executive Summary ..... Merrill

1. Introduction ..... Lavine
2. Technical Systems Evaluation (Charge Questions 1, 2, 5)
   - 2.1 Accelerator Physics Gerig*/SC-1
     - 2.1.1 Findings
     - 2.1.2 Comments
     - 2.1.3 Recommendations
   - 2.2 Superconducting Solenoids Wanderer*/SC-2
   - 2.3 Detector Systems Kettell*/SC-3
   - 2.4 Electronics/DAQ/Control Systems ..... Van Berg*/SC-4
3. Civil Construction (Charge Questions 1, 2, 5) Sims*/SC-5
4. Cost and Schedule (Charge Questions 2, 5) Merrill*/SC-6
5. Project Management & ES&H (Charge Questions 3, 4, 5) Loveless*/SC-7

*Lead

Expectations

- **Forward your sections for each review report (in MSWord format) to Casey Clark, casey.clark@science.doe.gov,**

  by Monday, June 11, 8:00 a.m. (EDT).